AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.6.2.1

Types of electromagnetic waves

Mark schemes and examiner comments

Tier	**Foundation**
Question groups	**9**
Available paper years	**2018–2025**

Using this booklet

1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

6.6.2.1 Types of electromagnetic waves

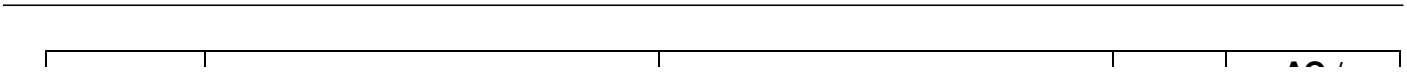
Answer 01 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	R		1	AO1 6.6.2.1
04.2	they have the same wave speed as visible light they have a lower frequency than gamma rays		1 1	AO1 6.6.2.1
04.3	any **two** from: • ageing of the skin • skin cancer • eye damage	 allow sunburn burn unqualified is insufficient cancer is insufficient allow mutation of genes in skin cells allow blindness	2	AO1 6.6.2.3
04.4	any **two** from: • gamma (rays) • X-rays • ultraviolet		2	AO1 6.6.2.4
Total			**7**	

6.6.2.1 Types of electromagnetic waves

Answer 01 · Mark scheme

June 2018 | 8464/P/2F | Original Q4



6.6.2.1 Types of electromagnetic waves

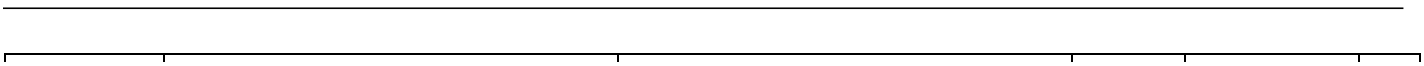
Answer 02 · Mark scheme June 2019 | 8464/P/1F | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
03.1	they changed direction	allow deflected/reflected/repelled	1	AO 1/1 6.4.1.3	E
03.2	diameter = $\frac{0.18}{6000}$ = 0.000 030 (nm)	an answer of 0.000 03 (nm) or 3.0×10^{-5} (nm) scores **2** marks allow 3.0×10^{-5} (nm)	1 1	AO2/2 6.4.1.1	E
03.3	A		1	AO 1/1 6.4.1.1	A
03.4	1100 (°C)		1	AO3/2b 6.3.2.3	G
03.5	8 (minutes)	allow 12 (minutes)	1	AO3/2b 6.3.2.3	G
03.6	the rate of change of temperature of the gold		1	AO3/1a 6.1.1.3, 6.3.2.2	A
Total			**7**		

6.6.2.1 Types of electromagnetic waves

Answer 02 · Mark scheme

June 2019 | 8464/P/1F | Original Q3



6.6.2.1 Types of electromagnetic waves

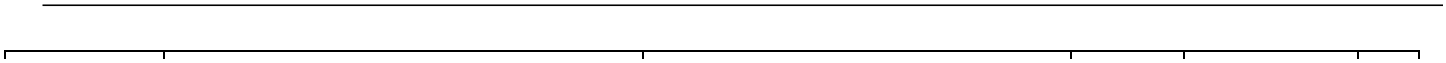
Answer 03 · Mark scheme June 2019 | 8464/P/2F | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
05.1	velocity frequency wavelength		1 1 1	AO1 6.6.2.3	G
05.2	so people are not exposed to (as much) gamma radiation because gamma radiation can damage human tissue	allow less gamma radiation reaches the Earth's surface allow increases the risk of cancer or (cell) mutation allow gamma rays are ionising ignore any reference to temperature / heating of the atmosphere	1 1	AO1 6.6.2.3	E
05.3	(microwaves) are used in (satellite) communications	ignore any reference to temperature / heating of the atmosphere	1	AO2 6.6.2.4	E
05.4	can cause skin cancer / premature ageing	allow sunburn allow eye / skin damage cancer on its own is insufficient	1	AO1 6.6.2.3	E
05.5	risk from UV radiation is highest in July / summer two correct readings from the bar chart which support their comparison	allow any sensible comparison of named months / seasons if no other mark scored, two correct readings from the graph scores **1** mark	1 1	AO3 6.6.2.3	E
Total			**9**		

6.6.2.1 Types of electromagnetic waves

Answer 03 · Mark scheme

June 2019 | 8464/P/2F | Original Q5



6.6.2.1 Types of electromagnetic waves

Answer 04 · Mark scheme June 2019 | 8464/P/2F | Original Q6

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
06.1	(4 - 0) + (10 - 7) **or** 4 + 3 **or** 10 - 3 7 (s)	an answer of 7 (s) gains **2** marks	1 1	AO2 6.5.4.1.5	E
06.2	gradient = $\frac{0-2}{24-14}$ (-) 0.2 (m/s^2)	an answer of 0.2 (m/s^2) gains **2** marks allow readings from any two points correctly substituted allow correct use of $a = \frac{\Delta v}{t}$	1 1	AO2 6.5.4.1.5	E
06.3	(there are no wires) to get tangled / disconnected	allow easier to move arms allow wires are inconvenient allow easier to transfer data	1	AO3 6.6.2.4	E
06.4	wave speed = frequency × wavelength	allow v = f λ allow any correct re-arrangement	1	AO1 6.6.1.2	E
06.5	300 000 000 = 2 400 000 000 × λ λ = $\frac{300\,000\,000}{2\,400\,000\,000}$ λ = 0.125 (m)	an answer of 0.125 (m) or 0.13 (m) scores **3** marks allow λ = 0.13 (m)	1 1 1	AO2 6.6.1.2	E
06.6	range is far enough (for most uses) power is not too great so the battery will not drain quickly	allow power not too great so the phone will not overheat allow the range per milliwatt is greatest or 4 metres	1 1	AO3 6.6.2.4	E

6.6.2.1 Types of electromagnetic waves

Answer 04 · Mark scheme

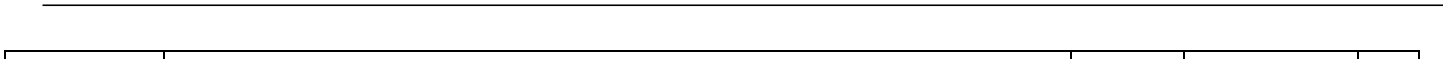
June 2019 | 8464/P/2F | Original Q6

Total			**11**		

6.6.2.1 Types of electromagnetic waves

Answer 04 · Mark scheme

June 2019 | 8464/P/2F | Original Q6



6.6.2.1 Types of electromagnetic waves

Answer 05 · Mark scheme

November 2020 | 8464/P/2F | Original Q3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	skin		1	AO1 6.6.2.4
03.2	dose is much lower than even slight increased risk of cancer dose	allow much less than 100 mSv	1	AO3 6.6.2.3
03.3	to reduce the dose of radiation (they are exposed to)	allow reduce the risk	1	AO3 6.6.2.3
03.4	sterilising medical equipment		1	AO1 6.6.2.3
03.5	they are ionising		1	AO1 6.6.2.3
03.6	**microwaves** data is transmitted / detected by (mobile) phone / WiFi / satellite **visible light** example of device / system description of how light is used	 allow signal / information for data allow bluetooth e.g. the internet transfers information via visible light in fibre optics e.g. image produced / seen on a TV / mobile phone	 1 1 1 1	AO1 6.6.2.4

6.6.2.1 Types of electromagnetic waves

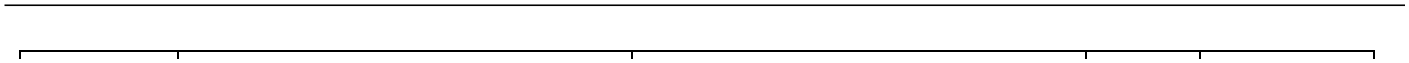
Answer 05 · Mark scheme

		allow any sensible suggestion for visible light, but the two marks must be linked		
Total			**9**	

6.6.2.1 Types of electromagnetic waves

Answer 05 · Mark scheme

November 2020 | 8464/P/2F | Original Q3



6.6.2.1 Types of electromagnetic waves

Answer 06 · Mark scheme

June 2022 | 8464/P/2F | Original Q1

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	energy		1	AO1 6.6.2.1

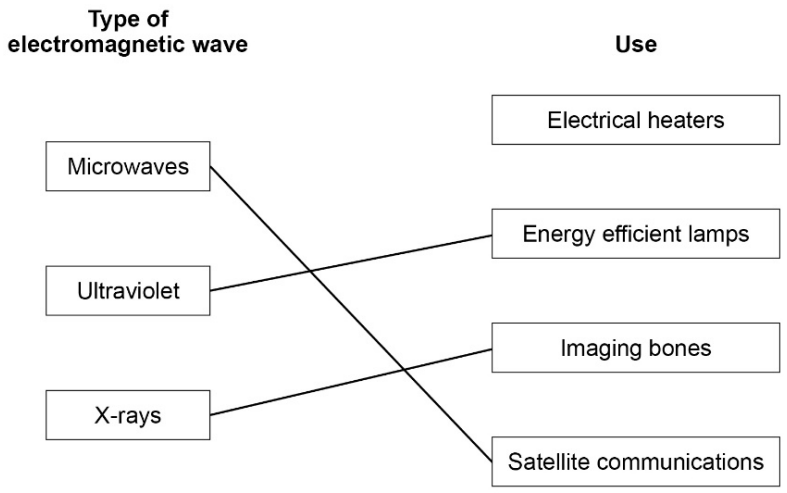
Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	frequency wavelength	either order	1 1	AO1 6.6.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	**A** = visible light **B** = gamma (rays / waves / radiation)	allow visible allow light	1 1	AO1 6.6.2.1

6.6.2.1 Types of electromagnetic waves

Answer 06 · Mark scheme

June 2022 | 8464/P/2F | Original Q1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	 additional line from a box on the left negates the mark for that box		1 1 1	AO1 6.6.2.4

Total Question 1		**8**

6.6.2.1 Types of electromagnetic waves

Answer 07 · Mark scheme

June 2023 | 8464/P/2F | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	**A** radio waves **B** microwaves **C** X-rays	allow **1** mark if 2 correct	2	AO1 6.6.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	**Similarity** any **one** from: • same speed (in a vacuum) • both transfer energy • both transverse **Difference** any **one** from: • gamma has a higher frequency • gamma has a shorter wavelength • gamma is more ionising • gamma is more penetrating	allow both can travel through a vacuum allow both are ionising allow both can harm living tissue allow both can be used for medical treatment / imaging allow gamma has more energy	1 1	AO1 6.6.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	refraction		1	AO1 6.6.2.2

6.6.2.1 Types of electromagnetic waves

Answer 07 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	wave speed = frequency × wavelength **or** $v = f\lambda$		1	AO1 6.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	$3.0 \times 10^{8} = f \times 5.0 \times 10^{-7}$ $f = \dfrac{3.0 \times 10^{8}}{5.0 \times 10^{-7}}$ $f = 6 \times 10^{14}$ (Hz)	 allow a correct rearrangement using incorrect powers of 10 allow a correct calculation of f using incorrect powers of 10 allow 6.0×10^{14} (Hz)	1 1 1	AO2 6.6.1.2

Total Question 6	9

6.6.2.1 Types of electromagnetic waves

Answer 08 · Mark scheme

June 2025 | 8464/P/2F | Original Q2

Question 2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	colour of water		1	AO1 6.6.2.2 RPA 21

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	initial temperature of water		1	AO1 6.6.2.2 RPA 21

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	measuring cylinder		1	AO1 6.6.2.2 RPA 21

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	$\frac{80.0 - 65.0}{5.0}$ = 3 (°C / minute)	allow $\frac{65.0 - 80.0}{5.0}$ allow $\frac{15.0}{5.0}$ allow – 3 (°C / minute)	1 1	AO2 6.6.2.2 RPA 21

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.5	*y*-axis labelled rate of change of temperature in °C / minute *y*-axis scale of 1.0 °C / minute per cm bars plotted correctly	unit must be present allow a tolerance of ± ½ small square ignore width of bars	1 1 1	AO2 6.6.2.2 RPA 21

6.6.2.1 Types of electromagnetic waves

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.6	answer between 5.0 and 6.1 (°C / minute)	do **not** accept 5.0 (°C / minute) do **not** accept 6.1 (°C / minute)	1	AO3 6.6.2.2 RPA 21

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.7	infrared		1	AO1 6.6.2.2 6.6.2.4 RPA 21

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.8	energy		1	AO1 6.6.2.2 RPA 21

Total Question 2	**11**

6.6.2.1 Types of electromagnetic waves

Answer 09 · Mark scheme June 2025 | 8464/P/2F | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	microwaves		1	AO1 6.6.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	gamma rays		1	AO1 6.6.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	the time taken for one wave to pass a fixed point		1	AO1 6.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	48 GHz = 48 000 000 000 Hz	allow 48 GHz = 48×10^9 Hz subsequent marks may be awarded if an incorrectly / not converted value of f is used	1	AO2
	$T = \frac{1}{48\,000\,000\,000}$		1	AO2
	$T = 2.08\ldots \times 10^{-11}$	allow 0.000 000 000 0208… allow 0.000 000 000 021 allow 2.1×10^{-11}	1	AO2
	s	allow seconds	1	AO1 6.6.1.2

6.6.2.1 Types of electromagnetic waves

Answer 09 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	any **one** from: • speed (in a vacuum / air) • they can travel through a vacuum • they transfer energy • they are transverse		1	AO1 6.6.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6	cables may not go to remote areas **or** it is expensive to lay cables	allow satellites may give faster data transfer	1	AO3 6.6.2.4

Total Question 5	**9**

6.6.2.1 Types of electromagnetic waves

Answer 02 · Examiner comments — June 2019 | 8464/P/1F | Original Q3

Question 3

03.1 Only about 30% of students could describe alpha particles as deflecting or rebounding from the gold atom. Many described the alpha particles as not going through, which was insufficient as it was given in the question. Some students thought alpha particles would be absorbed or destroyed.

03.2 A good attempt at this question to calculate the size of a nucleus using the ratio to the size of the atom was made by around 40% of students, with approximately 30% gaining both marks. A common mistake was to divide instead of multiplying. Some students tried to do the correct sum, but instead calculated 0.18 ÷ (1/6000) instead of calculating 0.18/6000. Nearly 10% of students made no attempt at this question. Using ratios is a mathematical skill in the specification.

03.3 This question testing knowledge of electron energy levels was correctly answered by just over 30% of students.

03.4 This question required students to identify that the temperature remains constant while a substance melts, and then read this temperature from the graph. 45% of students were able to do this correctly. Some student did not associate the constant temperature with the change of state, but more commonly they failed to correctly determine the scale on the temperature axis.

Answer 02 · Examiner comments — June 2019 | 8464/P/1F | Original Q3

03.5 About 35% of students could determine the time for the change of state from the graph. Reading values from graphs and using those values are required mathematical skills.

03.6 Nearly 60% of students correctly identified the gradient of the graph as the rate of change of temperature.

6.6.2.1 Types of electromagnetic waves

Answer 06 · Examiner comments June 2022 | 8464/P/2F | Original Q1

Question 1 (Low demand)

01.1 A little over 70% of students knew that waves transfer energy.

01.2 Nearly all students scored a mark on this question comparing electromagnetic waves, with approximately two thirds scoring both marks.

01.3 50% of students could name either visible light or gamma - of those that did only score one mark, gamma was the most common correct answer. Less than 25% of students scored 2 marks.

01.4 Over 95% of students scored at least one mark on this question. 65% scored two marks, with most that did failing to identify the correct use of microwaves. Approximately 15% of students scored all three marks.

Answer 07 · Examiner comments June 2023 | 8464/P/2F | Original Q6

Question 6 (standard demand)

06.1 Fewer than 25% of students could identify all the missing parts of the spectrum. 70% of students either scored zero marks or did not attempt the question. A significant number of students wrote answers that were nothing to do with the electromagnetic spectrum.

06.2 Only 2% of students we able to give a similarity and a difference. The similarity was more accessible and was how the majority of the 15% that scored one mark got the mark. Many

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6.6.2.1 Types of electromagnetic waves

Answer 07 · Examiner comments June 2023 | 8464/P/2F | Original Q6

identified that they are both transverse. For the difference, most students did not refer to a property of electromagnetic waves. A little over 15% of students did not attempt the question.

06.3 Approximately 20% of students knew that the process is refraction. A little over 15% of students did not attempt the question.

06.4 This question was well answered with over 90% of students getting the mark. Students were given the equation sheet, which will have contributed to the overall performance on this question.

06.5 25% of students were able to substitute correctly and give the correct answer to the question to the correct order of magnitude. Approximately 20% of students correctly rearranged and substituted but did not use their calculator to evaluate the numbers in standard form, so scored 2 marks.

6.6.2.1 Types of electromagnetic waves

Answer 08 · Examiner comments June 2025 | 8464/P/2F | Original Q2

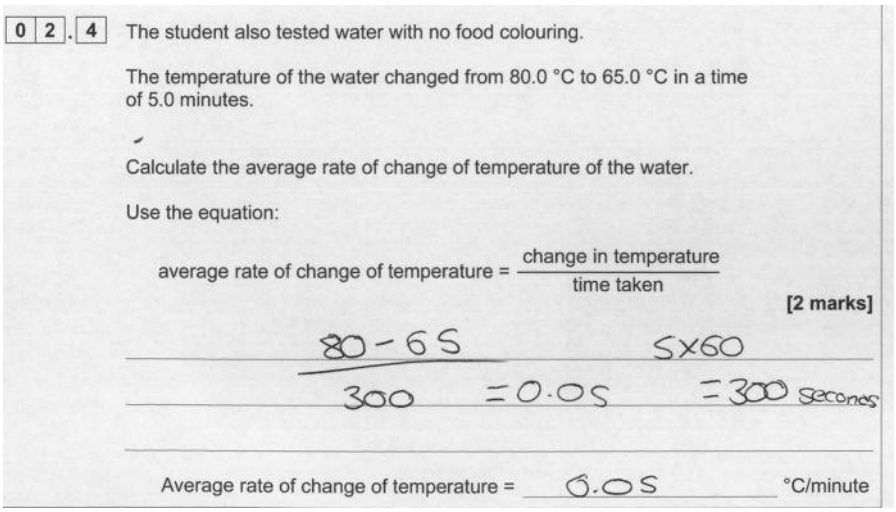
Question 2 (Low demand)

02.1 About half the students correctly identified the independent variable.

02.2 Only about 40% could identify a control variable.

02.3 Slightly more than 8 in 10 students recalled that a volume of water should be measured using a measuring cylinder.

02.4 This question was answered correctly by almost three quarters of students.
Of those who answered incorrectly, it was relatively common for students to divide a temperature by time, rather than dividing the change in temperature by time.



0 2 . 4 The student also tested water with no food colouring.

The temperature of the water changed from 80.0 °C to 65.0 °C in a time of 5.0 minutes.

Calculate the average rate of change of temperature of the water.

Use the equation:

average rate of change of temperature = change in temperature / time taken

[2 marks]

80 - 65 = 15
15 / 300 = 0.05
5 x 60 = 300 seconds

Average rate of change of temperature = 0.05 °C/minute

This student did not recognise that the answer line needed an answer given in °C/minute and calculated a rate in °C/second. Students who did this could still be awarded one mark.

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6.6.2.1 Types of electromagnetic waves

Answer 08 · Examiner comments

June 2025 | 8464/P/2F | Original Q2

02.5 The vast majority of students gained at least one mark on this question, with the most common mark awarded being for the scale on the *y*-axis. The most common mark not scored by students was because they either did not attempt to label the *y*-axis, did not include units in their label, or labelled the *y*-axis incorrectly. A common incorrect label was to write '*y*-axis' instead of writing 'rate of change of temperature in °C/minute'.

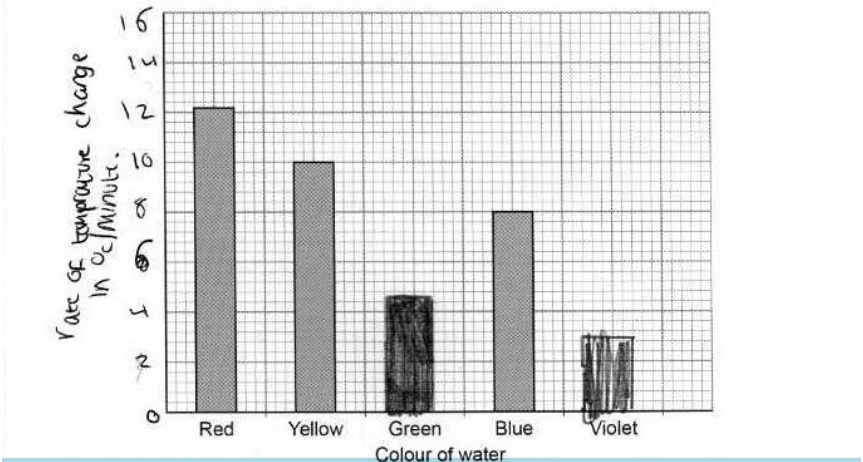
0 2 . 5 Complete **Figure 4**.

You should:

- label the *y*-axis
- add a scale to the *y*-axis
- draw bars for the green water and the violet water.

[3 marks]

Figure 4



This student added an incorrect scale. The height of the bars was marked independently from the scale the students chose – the heights needed to be consistent with the bars for Red, Yellow and Blue already drawn on the paper – so even if this student had drawn their two bars to be consistent with their incorrect scale, they would have not gained credit for this.

02.6 Just over half of students estimated a valid answer. A common incorrect approach was to determine the difference between the values for red and yellow, rather than to determine a value between these two values.

02.7 About 50% of students recognised that colour affects the rate of emission of infrared.

02.8 Slightly more than 60% identified that cooling occurred because the radiation transfers energy.

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6.6.2.1 Types of electromagnetic waves

Answer 09 · Examiner comments

June 2025 | 8464/P/2F | Original Q5

Question 5 (Low and standard demand)

05.1 About 40% of students recalled that microwaves are used to transfer data to satellites.

05.2 Slightly more than half the students remembered that gamma rays have the greatest frequency.

05.3 Just under half selected the definition for the period of a wave.

05.4 Nearly three quarters of students gained at least some credit, but a very small proportion of students were able to calculate the correct answer and give the correct unit. About a third of students scored 3 marks.
It was relatively common to see students writing incorrect calculations, such as '1/48 = 48', and there was a surprising number who decided to give their answer to one significant figure to this question, which is rarely 6.

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6.6.2.1 Types of electromagnetic waves

Answer 09 · Examiner comments

June 2025 | 8464/P/2F | Original Q5

0 5 . 4 Data is transmitted to the satellites by electromagnetic waves with a frequency of 48 GHz.

Calculate the period of waves with a frequency of 48 GHz.

Use the Physics Equations Sheet.

Choose the unit from the box.

[4 marks]

J	N/kg	s

48 ÷ 1000 = 0.048

1 ÷ 0.048 = 20.8

Period = 20.8 Unit S

This student clearly identified that 48 GHz needed to be converted to Hz but was unsure how to go about this. They scored 2 marks for the calculation, and a further mark for selecting the correct unit.

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6.6.2.1 Types of electromagnetic waves

Answer 09 · Examiner comments June 2025 | 8464/P/2F | Original Q5

05.5 Only a small minority of students gave a property that is the same for all electromagnetic waves. Many wrote about uses of the waves, rather than their properties, and it was relatively common to see answers that described the waves as something that can be used to transmit data, for example.

0 5 . 5 The satellites receive and transmit data using electromagnetic waves with different frequencies.

Give **one** property that is the same for electromagnetic waves with different frequencies.

[1 mark]

do not need mediums to travel through

This response was awarded the mark for the idea that electromagnetic waves can travel through a vacuum. Alternative wording to express correct physics is always acceptable, unless a mark scheme term is underlined.

05.6 Approximately a fifth of students gave an acceptable answer to this question. Many were confused about the difference between a connection to the internet and a connection to the national grid or to a power source, with many answers referring to solar power, and some referring to benefits to the environment of solar power.

0 5 . 6 Most homes are connected to the internet using cables.

Suggest **one** reason why homes in some areas of the UK are connected to the internet by satellites.

[1 mark]

satellites give off energy, each solar panel is charged by sun, therefore each ~~of~~ satellite gives electric energy

This response illustrates the incorrect link shown by many students between a connection to an electrical energy supply and a connection to the internet.

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